

## CLAIMS

We claim:

16 A method for determining the optimal tuning parameters in a linear controller, wherein

- a) the said linear controller is a device that receives an n-dimensional process variable  $y(t)$  from a process and sends an n-dimensional controller output signal  $u(t)$  to the said process, where  $t$  is the time variable and  $n$  is a positive integer,
- b) the said linear controller uses the following type of linear difference equation to calculate the controller output  $u_k$

$$Du_k = Er_k - Cy_k$$

where  $y_k = y(t_k)$  is the process variable at time  $t_k = t_0 + kT_s$ ,  $t_0$  is the initial time,  $T_s > 0$  is the constant sampling period,  $k$  is a non-negative integer called discrete time variable,  $u_k = u(t_k)$  is the controller output at time  $t_k$ , and  $u_k$  can be subject to lower limit and/or upper limit constraints placed on one or more of its components,  $r_k = r(t_k)$  is the set point at time  $t_k$ ,  $D$ ,  $E$  and  $C$  are  $n$  by  $n$  matrix polynomials in the unit backward shifting operator  $z^{-1}$  such that for any discrete time signal  $x_k$ ,  $z^{-1}x_k = x_{k-1}$ , and one or more of the said  $D$ ,  $E$  and  $C$  contain tuning parameters that are to be determined,

- c) the discrete time open-loop transfer function of the said process from the said controller output  $u_k$  to the said process variable  $y_k$  is  $A^{-1}B$ , where  $A$  and  $B$  are known  $n$  by  $n$  matrix polynomials in the unit backward shifting operator  $z^{-1}$ , and

d) the said method finds the optimal values for the said tuning parameters by minimizing the maximum of absolute values of all poles of the discrete time closed-loop transfer function  $(A+BD^{-1}C)^{-1}BD^{-1}E$  from the said set point  $r_k$  to the said process variable  $y_k$ .

17 A method as in Claim 16, wherein the said minimization of the maximum of absolute values of all poles of the closed loop transfer function  $(A+BD^{-1}C)^{-1}BD^{-1}E$  from the said set point  $r_k$  to the said process variable  $y_k$  is subject to constraints placed on the said tuning parameters

18 A method as in Claim 16, wherein  $D=(1-z^{-1})/T_s \cdot I$ , where  $I$  is the identity matrix of order  $n$ ,  $E=K_1$ ,  $C=K_1$  or  $C=K_1+K_2D$  or  $C=K_1+K_2D+K_3D^2$  or  $C=K_1+K_2D+K_3D^2+K_4D^3$  or  $C=K_1+K_2D+K_3D^2+K_4D^3+\dots+K_mD^{m-1}$ , where  $m$  is a positive integer, and the coefficients  $K_1, K_2, \dots, K_m$  are  $n$  by  $n$  constant matrices and are the said tuning parameters.

19 A method as in Claim 17, wherein  $D=(1-z^{-1})/T_s \cdot I$ , where  $I$  is the identity matrix of order  $n$ ,  $E=K_1$ ,  $C=K_1$  or  $C=K_1+K_2D$  or  $C=K_1+K_2D+K_3D^2$  or  $C=K_1+K_2D+K_3D^2+K_4D^3$  or  $C=K_1+K_2D+K_3D^2+K_4D^3+\dots+K_mD^{m-1}$ , where  $m$  is a positive integer, and the coefficients  $K_1, K_2, \dots, K_m$  are  $n$  by  $n$  constant matrices and are the said tuning parameters.

20 A linear controller as in Claim 16 with its structure and tuning parameter determined by Claim 18 and  $m>3$ .

21 A linear controller as in Claim 16 with its structure and tuning parameter determined by Claim 19 and  $m>3$ .